

Interferometric observations with IOTA and FLUOR

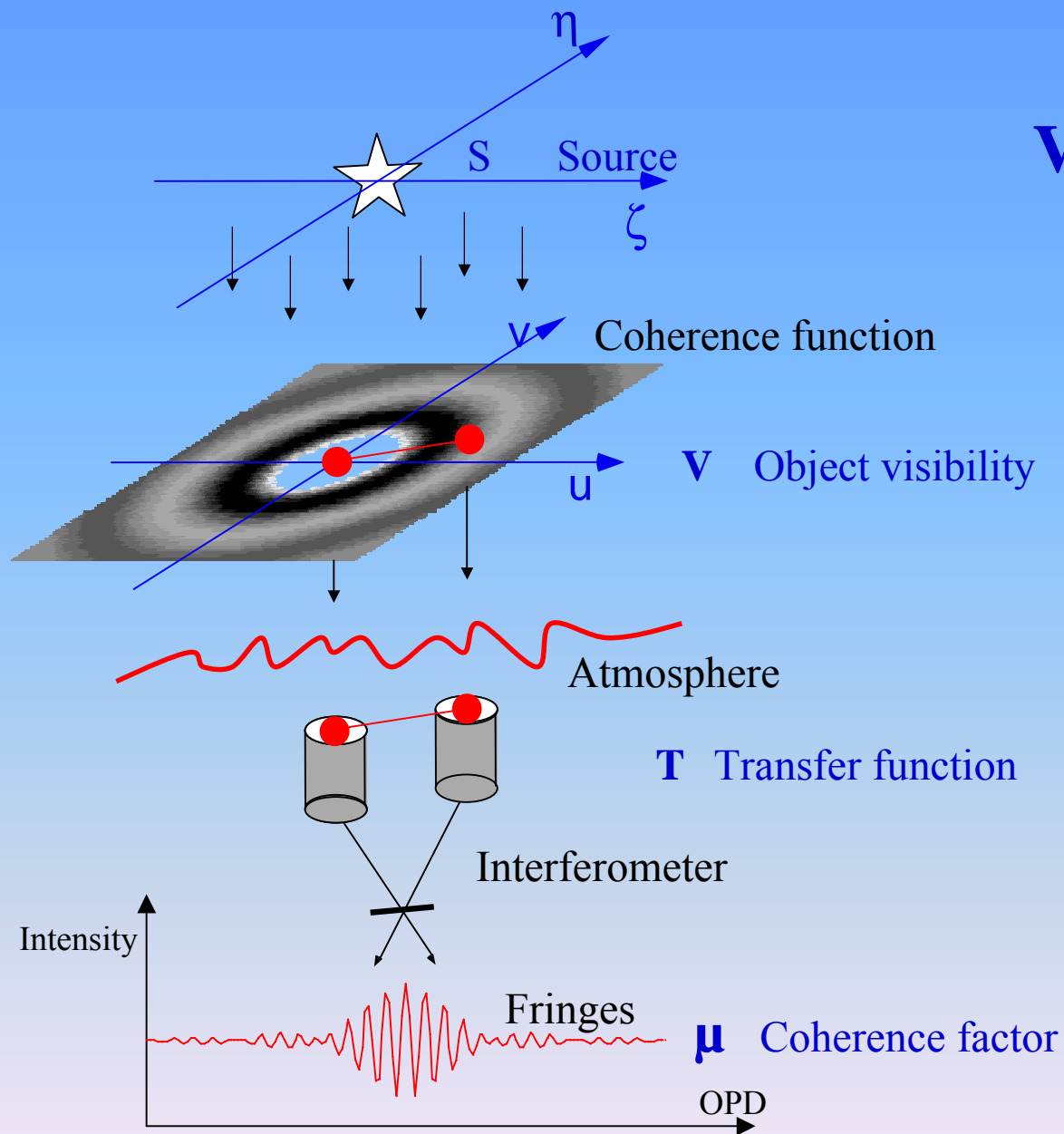
**Michelson Summer School
May 2001 session**

Flagstaff, Arizona

Vincent Coudé du Foresto
Observatoire de Paris
May 22nd, 2001

The four stages of an interferometric observation

- Observation preparation Vincent Foresto (morning)
Lab session
- Data acquisition Vincent Foresto (morning)
- Data reduction Guy Perrin (afternoon)
Lab session
- Data modelling and interpretation Bertrand Mennesson (afternoon)
Lab session



$$V(u,v) = \text{TF} [S(\eta,\zeta)]$$

Coherence and
object visibility

$$\mu = V \cdot T$$

T Transfer function

μ Coherence factor

From coherence factors to object visibilities

- Calibrator 1: $\mu_{\text{cal1}} \Rightarrow T_1 = V_{\text{cal1}} / \mu_{\text{cal1}}$
- Science target: $\mu^* \Rightarrow V^* = \mu^* \cdot T$
- Calibrator 2: $\mu_{\text{cal2}} \Rightarrow T_2 = V_{\text{cal2}} / \mu_{\text{cal2}}$

Stellar interferometry
is an art of calibration

A good calibrator is...

A source for which V can be predicted
(at the baseline considered)
with good accuracy and little bias

- Well modelled
- Well known
- Stable
- Observable with the same setup ($\Delta m_K, \lambda_{\text{eff}} \dots$)

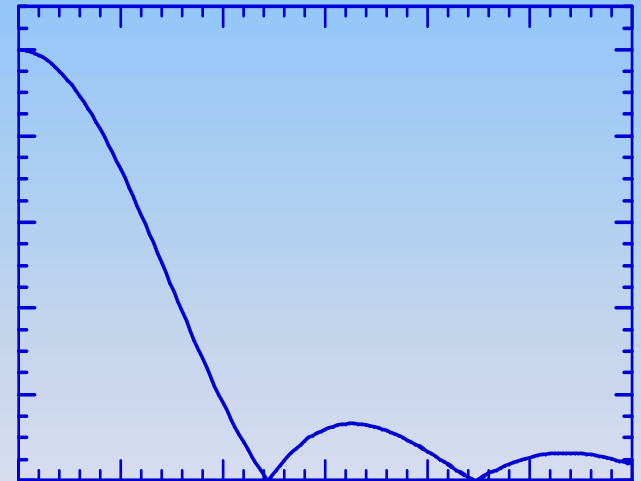
Common calibrator strategy

- Pick up a single star, non variable
- Use a uniform disk model
- Derive diameter from photometry (via T_{eff} and F_{bol})

Expected accuracy on ϕ_{UD} (not V!) :

- 5% in common cases
- 1% for photometric standards

(*cf. Cohen & al., A&A 117, 1864*)



Other strategies are possible!

Diameter from photometry (demo)

Know thy sources!

The screenshot shows a software window with a grey background. At the top, there is a text box containing 'R Leo' in red. To its right are two radio buttons: 'Calibrator' (unselected) and 'Selected source' (selected). Below these are two input fields: 'HD' with the value '84748' and 'HR' with the value '3882'. Further down is a label 'Coordinates (h.mmss) for Epoch' followed by an input field with '2000,00'. Below this are two input fields for 'Right Ascension' (9,473349) and 'Declination' (11,254365). The next row has three input fields: 'IR magnitude' (-2,63), ' λ_{eff} (μm)' (2,13), and 'SF (μm)' (13,20). Below these are two input fields: 'Spectral type' (M8 IIIe) and 'Estimated diameter' (28,18 +/- 0,050 m"). At the bottom is a text area containing 'V=4,40 at maximum' and 'Diameter from april 1996 run'. On the right side of the text area are two small arrow buttons (up and down).

R Leo

☐ Calibrator ☒ Selected source

HD **84748** HR **3882**

Coordinates (h.mmss) for Epoch **2000,00**

Right Ascension **9,473349** Declination **11,254365**

IR magnitude **-2,63** λ_{eff} (μm) **2,13** SF (μm) **13,20**

Spectral type **M8 IIIe** Estimated diameter **28,18 +/- 0,050 m"**

V=4,40 at maximum
Diameter from april 1996 run

- For a given observation, source status is either :

Science target

or

Calibrator

- Source information is used for data reduction
- Source ID needed for tracing correlations

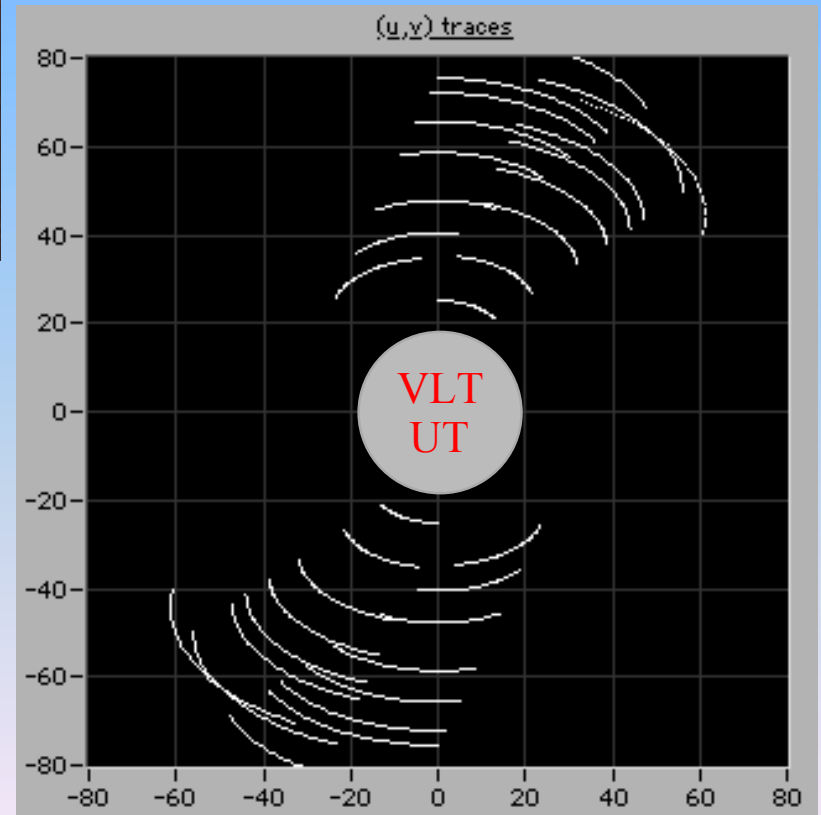
Mont Hopkins
Arizona

IOTA

Infrared and Optical Telescope Array



- 2 (3) relocatable 45cm siderostats
- Minimum baseline: 7m
- Maximum baseline: 38m
- Interchangeable focal instruments
- Operative λ (FLUOR):
 - 2–2.4 μm (K band)
 - 3.4 – 4 μm (L band)



Relocating the telescopes

- Fixed stations prealigned with kinematic mounts
- Telescope relocated with its shelter building
- 2 or 3 hours afternoon work... when everything goes well



Plot (u,v) traces (demo)

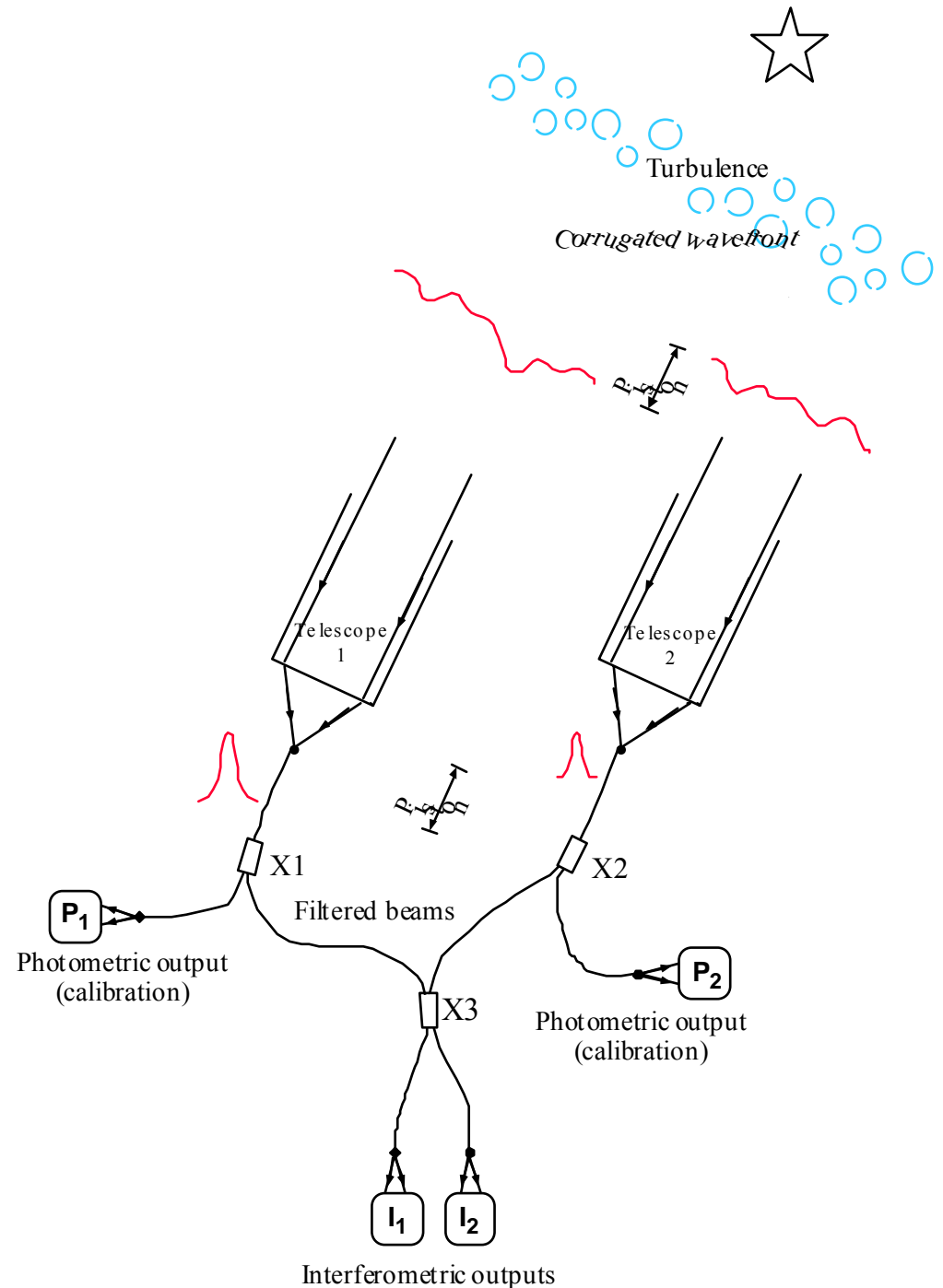
IOTA functional overview

- **Beam collection:** 45cm siderostats
=> sky coverage limitations
- **Beam stabilization:** fast tip-tilt
=> limit magnitude $V < 7$
- **Beam transport:** in vacuum pipes
- **OPD equalization (rough):** incremental long delay line
=> need to delay either North or South telescope
- **OPD equalization (fine):** continuous short delay line
=> need to relocate long delay line every 2.3m in OPD

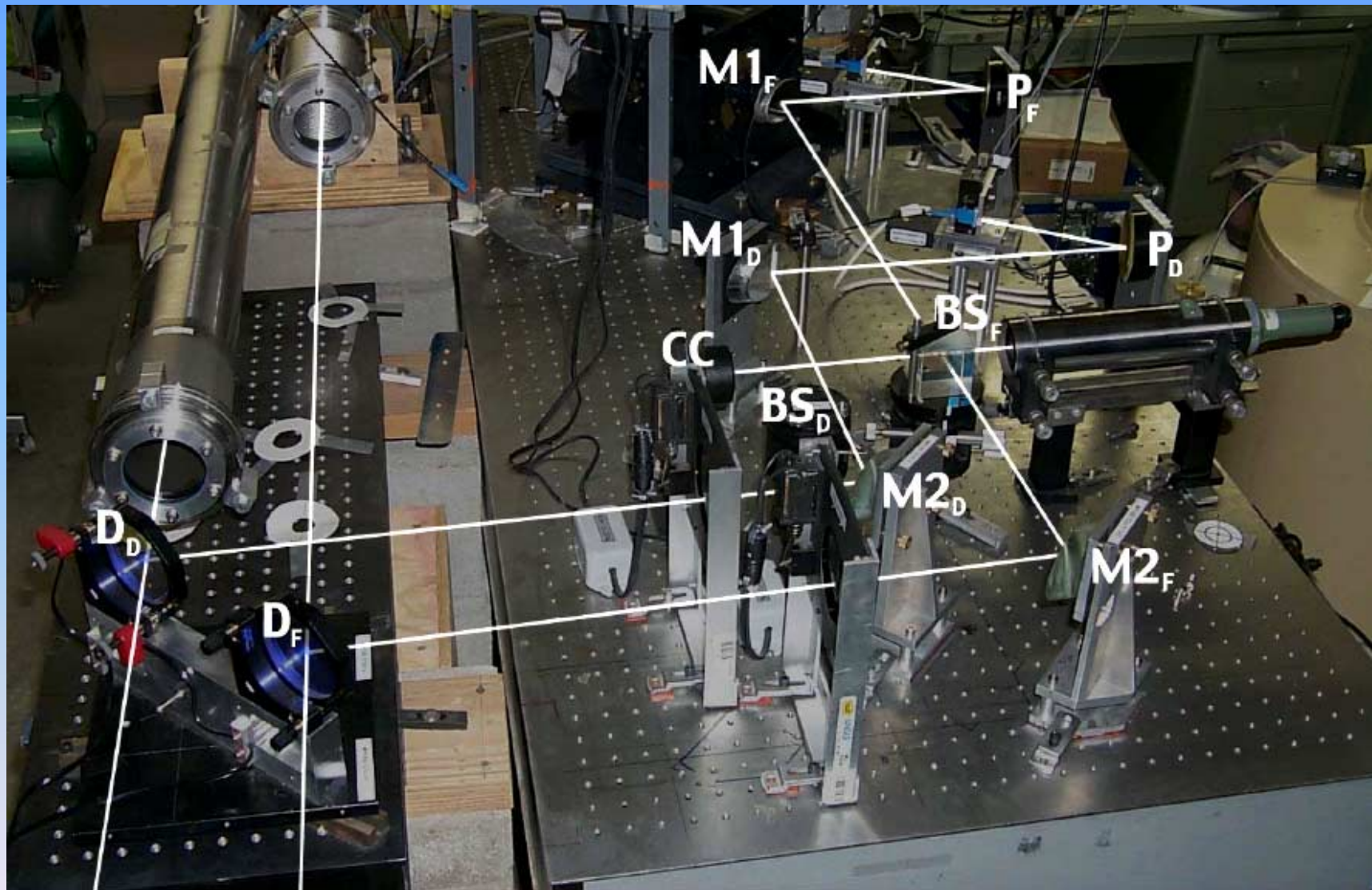
Plot observing schedule (demo)

FLUOR concept

- Two inputs:
 - Beam A and Beam B
- Single-mode fibers for:
 - « cleaning » of turbulent beams
 - Polarization control
 - beam combination (X-coupler)
- Coaxial beam combination
- Temporal OPD modulation
- Four outputs:
 - I_1 , I_2 , P_A and P_B



FLUOR layout





Optical pathlength difference modulation

- Temporal encoding through scanning mirror :

$$\text{OPD} = v_{\text{scan}} \cdot t$$

- Maximum range :

$$-90\mu\text{m} < \text{OPD} < +90\mu\text{m}$$

- Scan velocity :

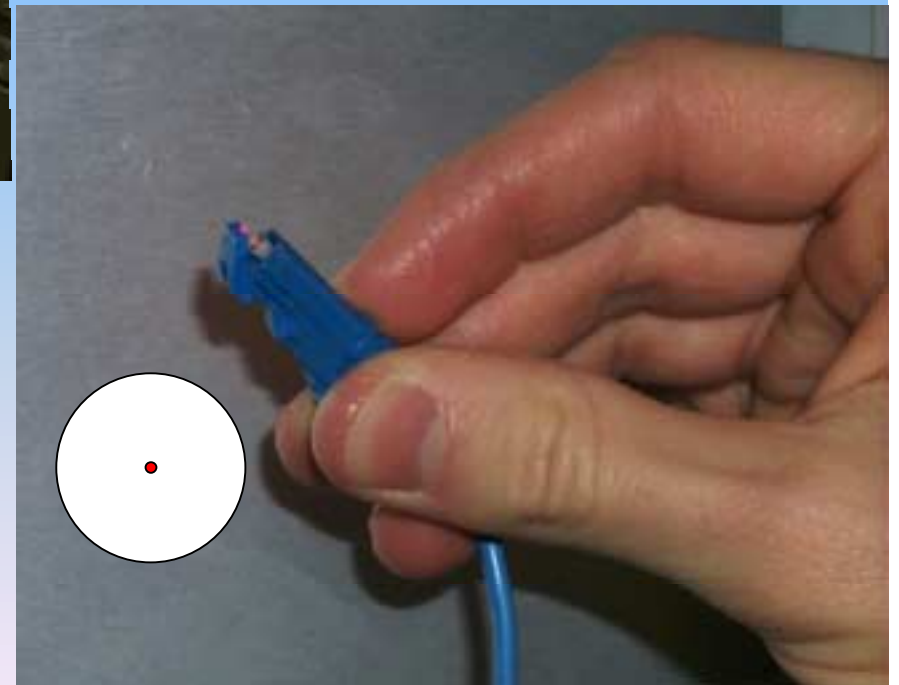
$$v_{\text{scan}} = 220 \text{ — } 1100\mu\text{m/s}$$
$$\Rightarrow f_{\text{fringes}} = 100 \text{ — } 500\text{Hz}$$





Guided optics components

- Single-mode waveguides
- Fluoride glass for IR transmission
- 9 μm core, 125 μm cladding
- $\lambda_c = 1.9\mu\text{m}$



FLUOR observational constraints

- Productivity : 4 – 6 sources / hour
- Limit magnitude : $K \sim 4$
- Typical accuracy : $dV / V \sim 1\%$

